

IRSN

FLAMME_S code qualification

- 4 series of tests for qualification :
 1. Centred Pool fires (IPSN tests)
 2. Pool fires against a wall (IPSN tests)
 3. Multi- room tests ; centred fire (Cooper and al.) ;
 4. Multi rooms tests ; fire against a wall (Peacock and al.)

- *Objectives of IPSN tests*
 1. *To study the development of a pool fire in a semi-confined compartment with forced or natural ventilation*
 2. *To study the interaction between the wall and the fire*

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Fuels

Chemical formula

➤ TPH	$C_{12}H_{26}$
➤ 70% TPH - 30% TBP	70% ($C_{12}H_{26}$) – 30% ($C_{12}H_{27}O_4P$)
➤ Ethanol	C_2H_6O
➤ Mineral Oil (DTE medium)	$C_{31,34}H_{63,9}$
➤ Domestic fuel	$C_{15,55}H_{29,3}$
➤ Methane	CH_4

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- fire pool against the south wall
- PLUTON facility : V = 400 m³, L×l×H
9 m×6 m×7,6 m concrete walls
- the normal ventilation flow rate of the room : 3
volume changes per hour.

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Area of the pool (m ²)	Mean HRR kW	Kind of fuel	Test
0.4	360	TBP/TPH	FLIP1
0.4	215	Ethanol	FLIP1A
1.0	645	TBP/TPH	FLIP2
1.0	510	Ethanol	FLIP2A
1.5	910	TBP/TPH	FLIP7

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*Experimental data***Experimental cell :**

- Liquid fuel mass
- Plume temperature
- Gas temperature
- Wall temperature
- Total and radiative thermal fluxes on the walls
- Gas pressure
- Flow velocity in the plume
- Species concentrations : O₂, CO₂, CO, soot (C)

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Ventilation network

- Admission and extraction flow rates
- Pressures at different location (ex : up and down stream of the filters)
- Gas temperature
- Species concentrations : O₂, CO₂, CO, soot (C)

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➤ Data used to qualify FLAMME_S code

Input data :

- ✓ Mass Combustion rate : *measured mass loss rate in function of time*
- ✓ Soot fraction : *mean experimental value (mass balance after the test)*

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Test Data used for the comparison with code results

- ✓ Gas temperature : mean temperature , lower zone temperature, upper zone temperature
- ✓ Gas pressure
- ✓ Gaseous species fractions : O₂, CO₂, CO
- ✓ Wall temperatures
- ✓ Ventilation network : gas flow rates (admission and extraction)

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Comparison of the experimental and calculated values

- Experimental and calculated values plotted on graphs
- Determination of the relative variations between the maximum values
- Determination of the largest deviations

Qualification criteria :

Relative deviation between experimental and calculated values less than 20% for the main variables
gas mean temperature, gas pressure, oxygen concentration, wall temperature

*lower and upper zone temperatures interface height
admission and extraction gas flowrates*

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Domain of qualification

- room walls : concrete or of steel.
- height of the room : equal or greater than the smallest horizontal dimension of the room.
- room : sealed or connected to the outside with vertical openings or with a ventilation network (flow rate : 3 to 5 volume changes per hour).
- fire pool : centered in the room or against a wall (see FLIP tests).
- fuel : mineral oil or of an organic liquid.
- the pool area to the area of the horizontal surface of the facility ratio : less than 5%
- combustion rate of the fuel : input data
- heat release rate to the volume of the facility ratio is less than 5kW/m³

Future steps for qualification

- Electrical cabinets fires tests (CARMELA, CARMELO tests) :
 - ✓ to develop a model for describing the heat release rate evolution for this material
 - ✓ First series of tests is achieved ; an empirical model is proposed ; complementary analytical and global tests are planed in 2002
- Multi room tests :
 - ✓ DIVA tests (first preliminary campaign : 2002) : study of smoke and heat spreading in multiroom configurations (natural and mechanical ventilation)

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➤ Comments :

- ✓ Results are not satisfying for calculation of large pool fires (ex : 2 MW, 400 m³)
- ✓ Limitation of zones model to simulate fires with large vertical thermal gradient into the gaseous volume

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Area of the pool (m ²)	Fuel	Facility : Volume m ³ (L×l×H) ou (S×H) wall material	Ventilation conditions	Test
0,0314	Mineral oil (DTE medium)	4,35 m ³ (0,856 m ² ×5,35 m) (steel wall)	confined	LPI 7
0,0314	Mineral oil (DTE medium)	4,5 m ³ (2,011 m ² ×2,24 m) (steel wall)	confined	LPI 9bis
0,0629	Mineral oil (DTE medium)	4,5 m ³ (2,011 m ² ×2,24 m) (steel wall)	confined	LPI 10
1	70% TPH - 30% TBP	400 m ³ (9 m×6 m×7,6 m) (concrete wall)	mechanical (3 V/H) ¹	LIC 2.3
1	70% TPH - 30% TBP	2000 m ³ (10 m×10 m×20 m) (concrete wall)	Natural	LIC 2.8.1
1	70% TPH - 30% TBP	3600 m ³ (20 m×15 m×12 m) (concrete wall)	confined	LIC 2.CA
1	TPH	3600 m ³ (20 m×15 m×12 m)	confined	LIC 2.CB

¹ The value indicated corresponds to the ventilation flow rate at the start of the fire.

1	Mineral oil (DTE medium)	400 m ³ (9 m×6 m×7,6 m) (concrete wall)	mechanical (5 V/H)	LPI 11A LPI 11 PEPSI 1
1	ethanol	400 m ³ (9 m×6 m×7,6 m) (concrete wall)	mechanical (5 V/H)	LIC 1.14
2	Mineral oil (DTE medium)	400 m ³ (9 m×6 m×7,6 m) (concrete wall)	mechanical (5 V/H)	LPI 12
5	70% TPH - 30% TBP	2000 m ³ (10 m×10 m×20 m) (concrete wall)	Natural	LIC 2.8.5
5	Mineral oil (DTE medium)	2000 m ³ (10 m×10 m×20 m) (concrete wall)	Natural	LPI 13
5	Domestic fuel	2000 m ³ (10 m×10 m×20 m) (concrete wall)	Natural	LPI 19

Q (kW)	½ corridor	¾ corridor	corridor and lobby	Corridor 1/2 door	Corridor 1/4 door	Corridor 1/8 door
25	X	X	X	X		
100	X	X	X	X	X	X
225	X	X	X	X		
Ramp fire	X	X	X	X		

List of Cooper tests ↑

↓ *List of Peacock's tests*

Test number	Q (kW)	Door (corridor)	Third room
1	100	Open	No
4	100	Open	Yes
5	300	Open	No
6	300	Closed	Yes
7	300	Open	Yes
8	500	Open	No
9	500	Open	Yes